Open, Programmable, Secure 5G (OPS-5G) Program

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Goal

Create open source software and systems enabling secure 5G and subsequent mobile networks

From 4G to 5G:

5G Benefits:
10-100x bandwidth
1000x capacity
0.1x latency
100x connections
10x device battery life
Programmability:
- have it your way

OPS-5G

Open Source:
- Increased code visibility
- Hardware/Software decoupling

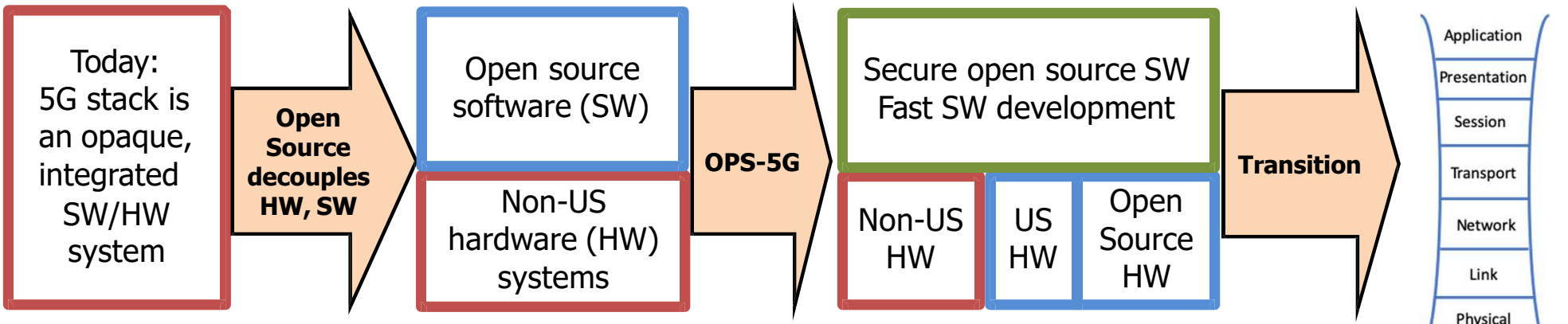
Programmable:
- Bespoke networks
- Adaptation velocity

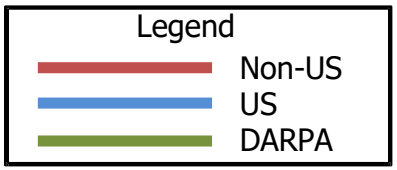
Secure:
- Increase trust at softest points
- Increase defender velocity

5G Risks:
Many untrusted devices
Opaque proprietary software
Non-US hardware
Misuse of programmability
viz Javascript on WWW

Vision: Open, Programmable, Secure 5G (OPS-5G)

OPS-5G will develop a portable standards-compliant network stack for 5G mobile that is free, open source, and *secure by design*



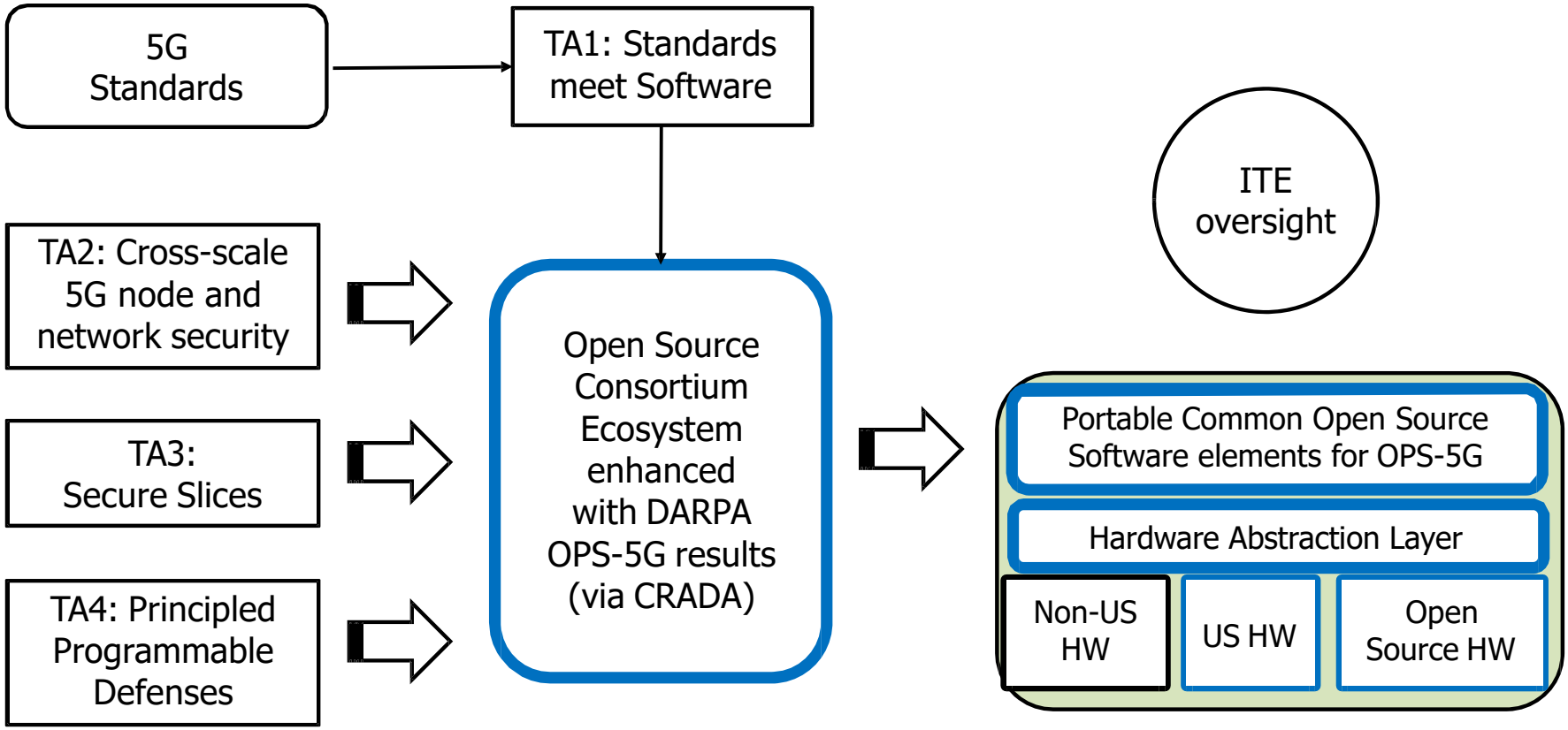


What's New in OPS-5G?

Today	No OPS-5G?	OPS-5G Benefit / TA
Vendor proprietary software	Open source lags in code velocity	Machine Translation adds code velocity TA1: Standards Meet Software
5G-attached Internet of Things (IoT)	Cost pressures elide security	Scalable cost-effective architectural solutions TA2: Many-scale 5G node and network security
Suspect shared resources	Vulnerable to, e.g., side channel leaks	Trusted nets on untrusted infrastructure TA3: Secure slices
5G features open new attacks	Adversary control / denial / agility	Quick and flexible response TA4: Principled programmable defenses

OPS-5G overcomes unmet 5G security needs

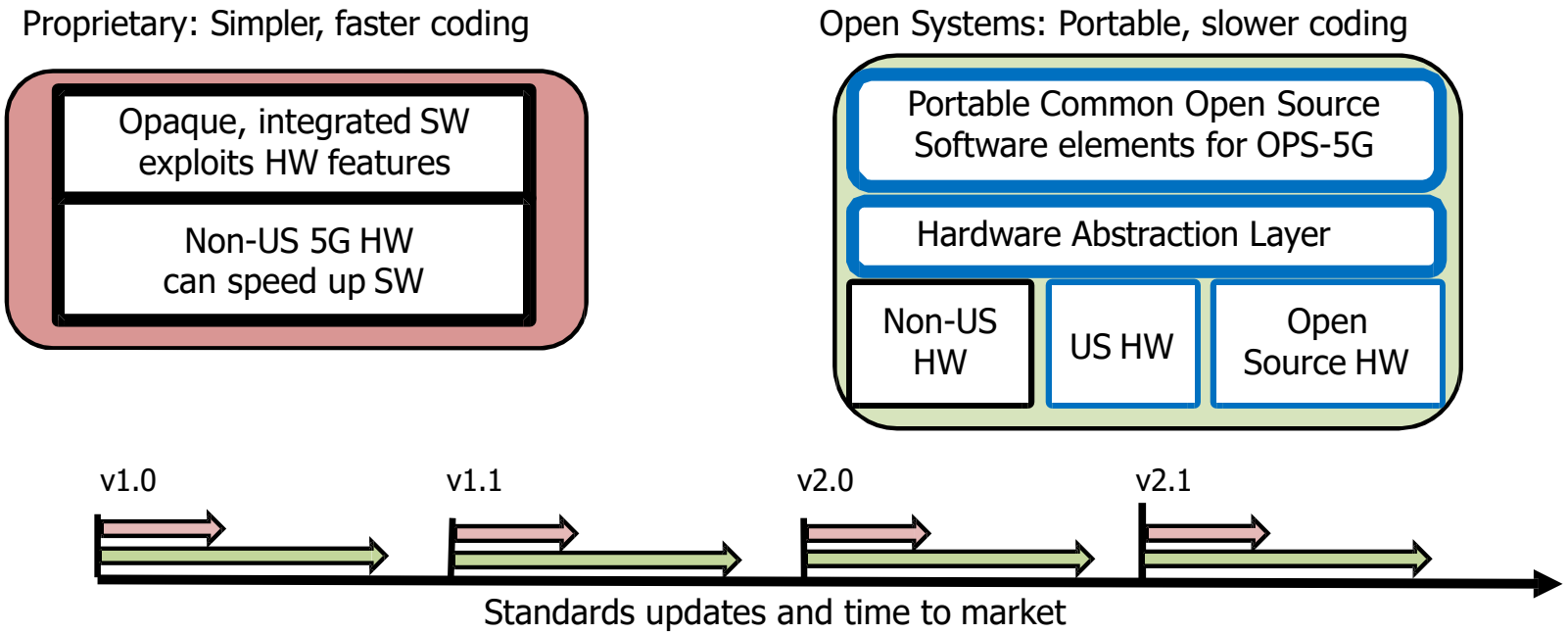
Program Structure and Transition Plan



TA1 Challenge: Hardware/Software Decoupling is Hard!

Issues:

- Requires collaboratively developed, well-defined standards (IETF, etc.)
- Portability requirement increases development complexity and time
- Increased development time exacerbated by evolving standards

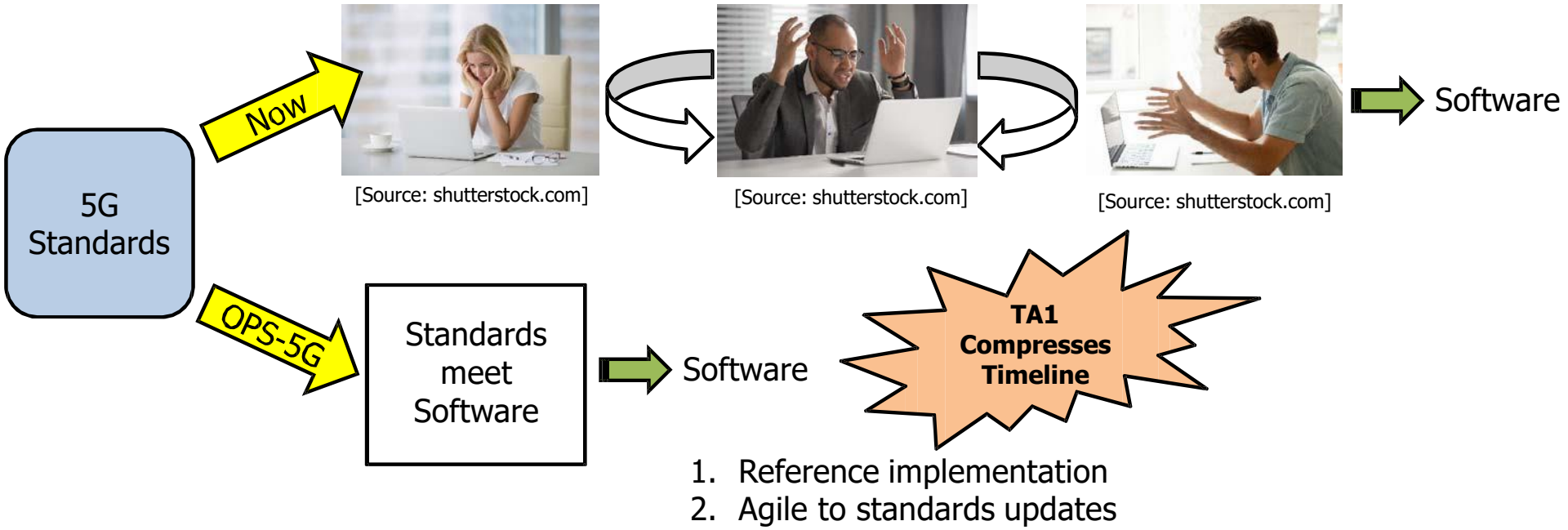


Technical Area 1 – Standards meet Software

Goal: Accelerate development of open source software from standards

Approach: Extend NLP to generate formal machine-readable representation of standards

- Rigid document structure, limited domain in 5G standards enable automated translations
- Promising pathfinders (KANT, ARSENAL, TAILCM)



1. Reference implementation
2. Agile to standards updates

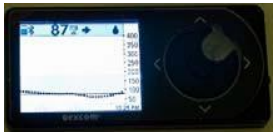
TA2 Challenge: Security at scale

Issues:

- Security across devices with vastly disparate SWaP
- Cost-effective solutions ($2, 5mm^2)
- Requires decentralized operation, ease of use
- Must support authentication, remote attestation, group membership, etc.

[Source: David Culler, UC Berkeley]

1. Patient data download to infected medical office PC via USB results in malware upload



[Source: Jonathan Smith, DARPA]

2.Malware infects more (possibly trusted) devices

[Source: Jonathan Smith, DARPA]

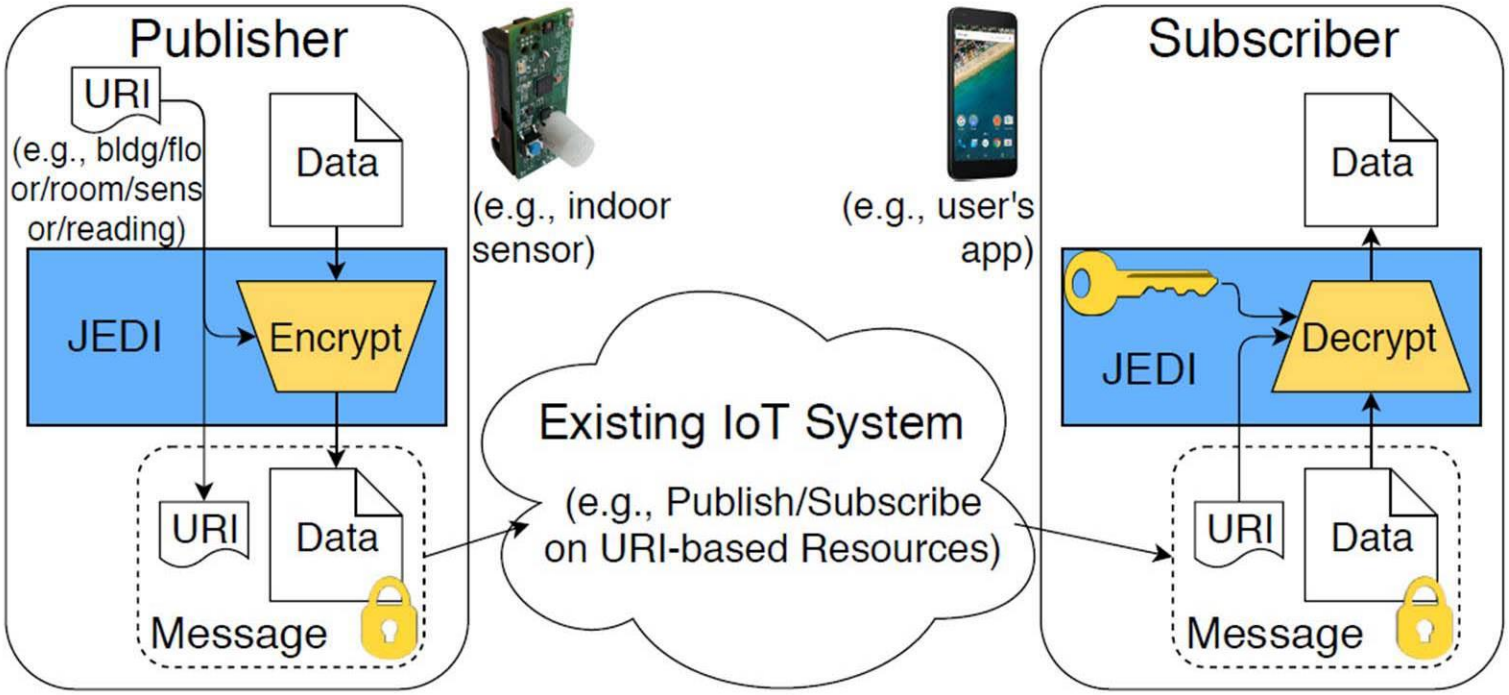
3. Resulting in the Mother of all Botnets

[Source: Fortinet.com]

Technical Area 2 – Many-scale 5G node and network security

Goal: Cost-effective SWaP-conscious crypto, scalable security protocols

Possible Approach: Extend Berkeley JEDI

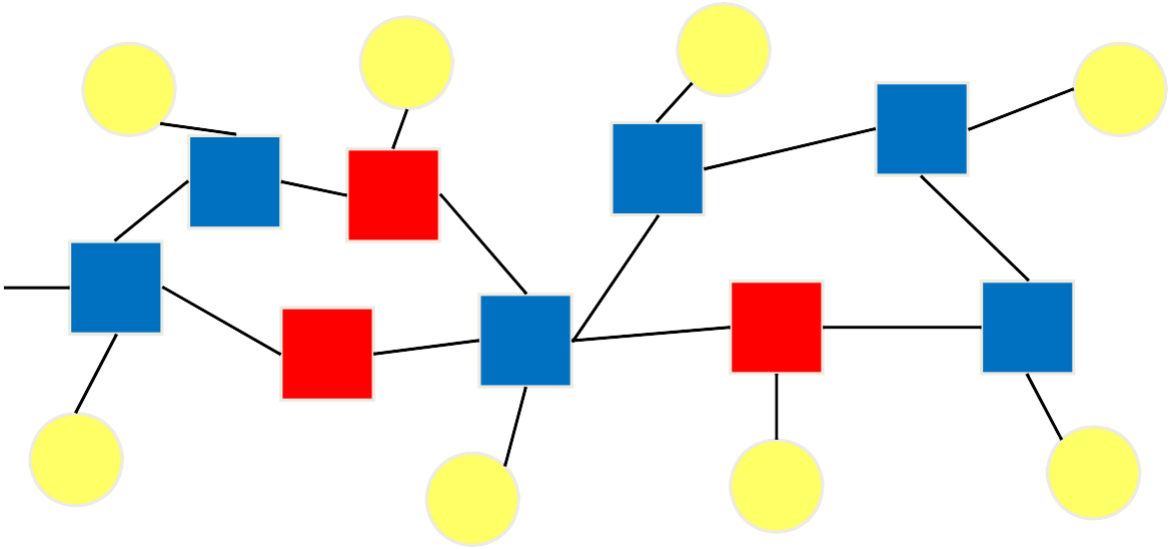


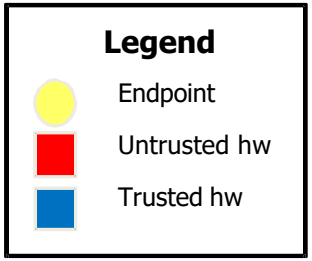
[Source: David Culler, UC Berkeley]

TA3 Challenge: Operating over Untrusted Nodes and Nets

Network slices:

Virtual networks with configurable performance characteristics operating over shared hardware





Issues:

- Sharing of hardware/resources create potential timing channels
- Threats from untrusted network elements: Who owns that net?

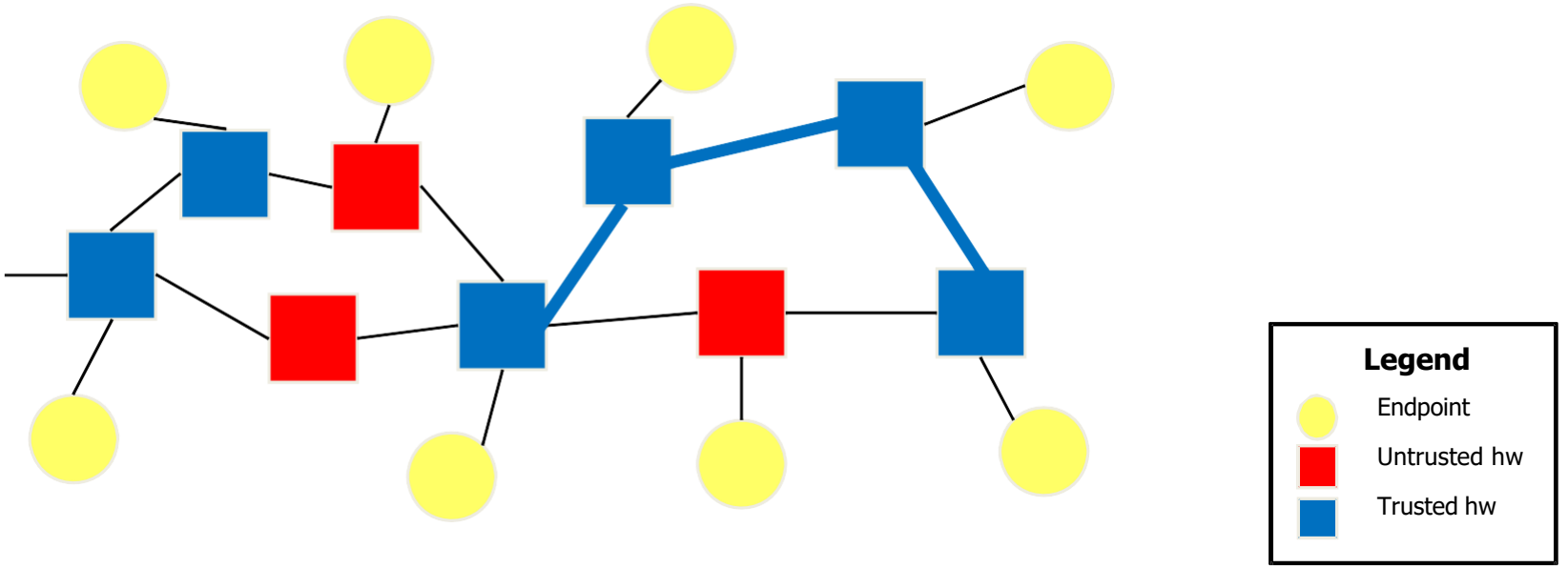
Technical Area 3 – Secure Slices

Goal: Provide security over network resources provided by and shared with unknown entities

Approaches: Route selection avoids:

(1) Nodes that can't attest

(2) Shared resources

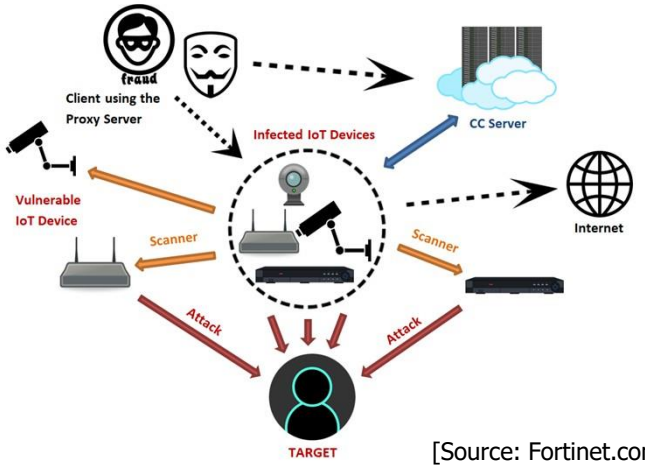


TA4 Challenge: Adaptive Adversaries at Tera-node Scale

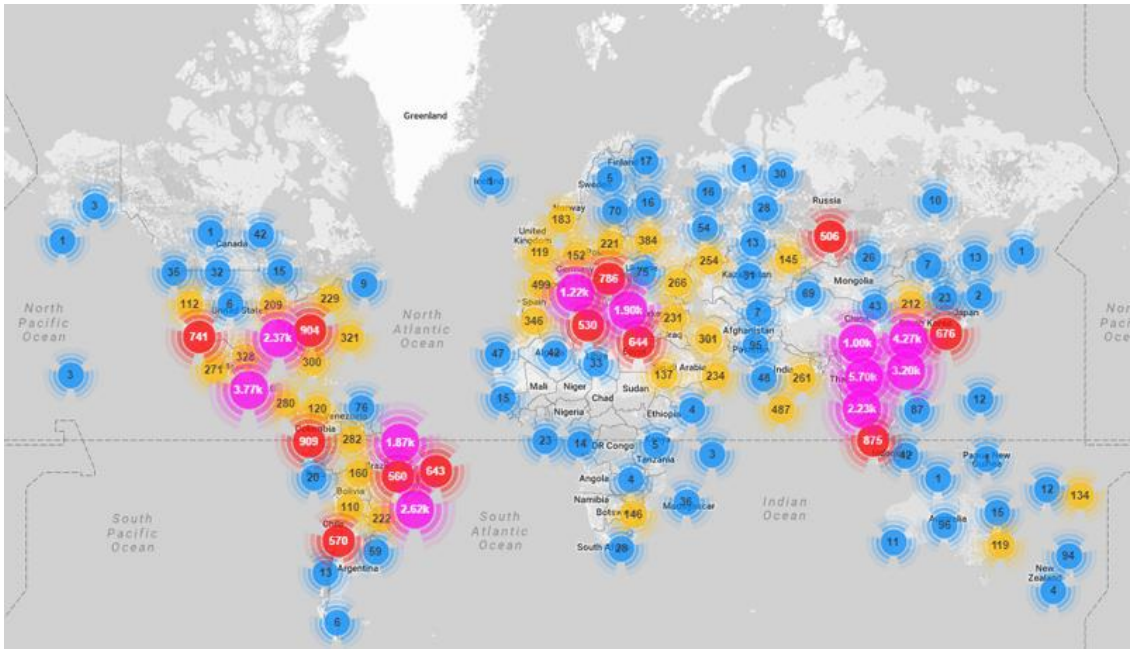
Issue:

- 5G programmability radically increases risk of network attack

Exemplar: IoT DDoS (Mirai)



[Source: Fortinet.com]



Worldwide Mirai Botnet Infections [Source: Securityledger.com]

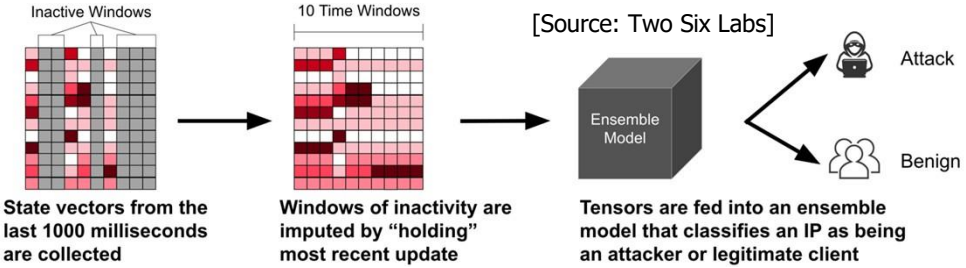
Peak Size: ~600K nodes (cameras, routers, game boxes)
Peak volume: 623 Gbps against Krebs [Antonakakis17]
5G will have 60-600 billion (!) nodes by 2023!!

Technical Area 4 – Principled Programmable Defenses

Goal: Increase security against DDoS attacks

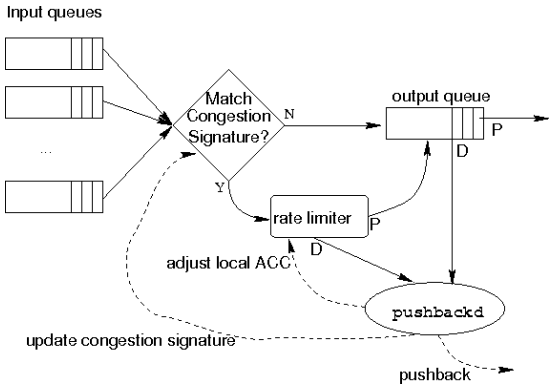
Approach: Use programmable elements of 5G for defense

- Example: Botnet early warning using machine learning (XD3: Two Six Labs)



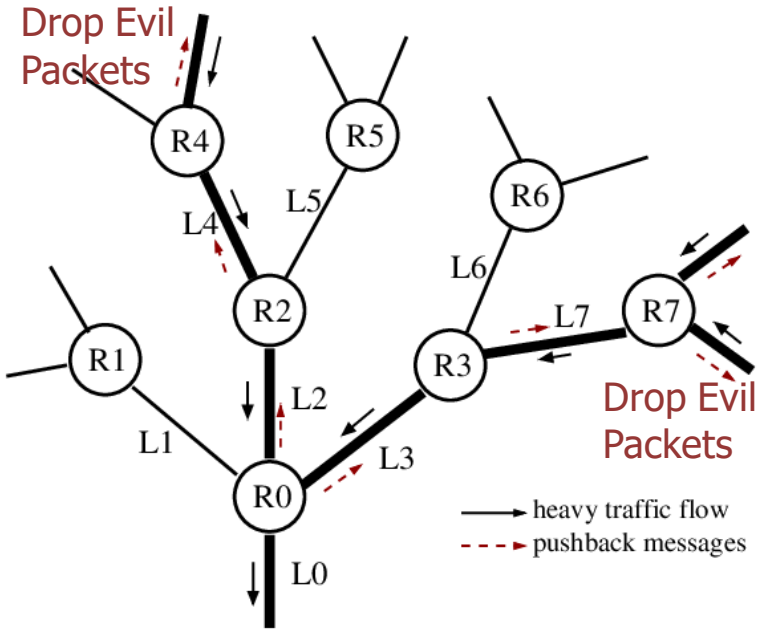
[Source: Two Six Labs]

- Warning triggers deployment of Ioannidis and Bellovin "Pushback"



[Source: Steven Bellovin, Columbia Univ]

On-the-fly node programmability enables real-time distributed detection and diagnosis of attacks and deployment of appropriate defenses



[Source: Steven Bellovin, Columbia Univ]

Notional OPS-5G Technical Area and Program Metrics

	Phase 1 (18 months)	Phase 2 (18 months)	Phase 3 (12 months)
TA1 Precision, recall	60%, Independent Test & Evaluation (ITE)-chosen document	80%, ITE-chosen content and doc	95%, ITE-chosen content and doc
TA2 Security/SWaP	256-bit "encrypt & sign" in < 10 sec using < 70% battery	Resist ITE penetration test of many-to-many IoT for 4 hrs using < 50% battery	Resist ITE penetration test on 10K IoT+User Equipment for 2 days using < 25% battery
TA3 Reduction in secure slice timing channel capacity	3x	10x	50x
TA4 Mirai mitigation time	60 sec on 1G emulated nodes	1 sec on 10,000 IoT nodes	60 sec on 1T emulated nodes
Milestone Demonstrations	Secure voice call between DARPA and USR&E test-site	Data from 1K devices to DARPA over untrusted hardware	Commercial availability in User Equipment and at least 1 US mobile network operator

Independent Test and Evaluation (ITE)

- Voice of the Offense (for Performers)
- Evaluation and Assessment (for DARPA)
- Will use USG entity, e.g., NSA, LTS, Sandia

OPS-5G Summits and 5G Standards

- Transition requires adoption of OPS-5G designs into formal 5G standards
- Program will continually engage with 5G standards committees and US carriers at "summits"

www.darpa.mil